SwRI Project 08-31088
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A report on

A VEHICLE FUEL TANK FLUSH EFFECTIVENESS EVALUATION PROGRAM

In response to:
CRC Project No. CM-138-01/1

Prepared for:

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I. INTRODUCTION

Southwest Research Institute (SwRI) conducted this vehicle test program at the request of the Coordinating Research Council (CRC) to investigate the effectiveness of vehicle fuel system flush procedures. Phase I of the program consisted of three flush procedures (A, B, and C) on five different vehicles as specified by CRC. A fuel with ethanol content was installed into the vehicle fuel tank, an initial sample was taken, the fuel flush technique was conducted, a four gallon fill was added to the tank to begin a driveability test, and a final fuel sample was taken. The ethanol content in the initial and final fuel samples was measured using the ASTM D 5599 method. After review of the results in Phase I, CRC directed SwRI to conduct Phase II consisting of four flush procedures on two of the original five vehicles.

II. BACKGROUND

To enhance air quality, oxygenated fuels have been introduced into "nonattainment" areas of the U.S. to reduce vehicle emissions. Since ethanol is a common oxygenate, work has been performed by CRC to determine what effect ethanol fuel blends have on vehicle driveability. During these evaluation programs, it has been necessary to change fuels in vehicle fuel systems from oxygenated to hydrocarbon–only fuels. It has become a concern within CRC of possible carryover of ethanol from potentially inadequate flushing techniques. Phase I of this program provides CRC with information to define ethanol carryover for flushing procedures designated A, B, and C. Phase II provides carryover data on modified C, E, modified E, and F procedures which were developed to enhance the fuel flush effectiveness.

III. TEST PROCEDURES

A. TEST FUELS

Two fuels were used for this program. Haltermann EEE emissions test fuel was designated as Fuel H. Fuel H and denatured ethanol were blended to yield Fuel E with approximately 10% ethanol by volume. Ten new 55-gallon drums were purchased for the program. Five drums were labeled and filled with Fuel E and five more with Fuel H. Should the CRC decide to conduct further tests, this was sufficient volume of Fuel E to run a duplicate set of flush procedures A, B, and C on each vehicle.

Two new hand fuel pumps were purchased and labeled for each fuel type for this program. One drum each of Fuel E and Fuel H was used to flush the hand pumps, the funnels, and the calibrated cans. These flush drums were removed from the area and not used for testing. The hand pumps were then installed in the appropriate test fuel drum and a sample of Fuel E and Fuel H were drawn and delivered to the SwRI Petroleum Research Department for analysis. Refer to the photograph in Appendix A of a 55-gallon drum of Fuel E, which was ready for test. The following is a table summarizing the analytical results on the test fuels.

Table 1 – Test Fuel Analyses

Test Method	Fuel E	Fuel H
ASTM D 4815 Oxygenate Content Ethanol (wt% / vol%)	10.18 / 9.62	Not Run
ASTM D 5599 Oxygenate Content Ethanol (wt% / vol%)	10.02 / 9.47	<0.01 / <0.01
ASTM D 4052 Specific Gravity	0.7493	0.7455

B. FUEL HANDLING CONTAINERS

For accuracy, the amount of fuel added to a vehicle was measured by calibrated fuel cans which have graduated necks to increase the accuracy of the volume measurement of the fuel. Refer to the photograph in Appendix A of two calibrated cans. One set of dedicated calibrated fuel cans, a one and a two gallon can, was labeled and used for adding Fuel E and another set of dedicated calibrated fuel cans was used for adding Fuel H. The cans were thoroughly flushed with the appropriate fuel prior to starting the test program. A glass 2000 ml graduated cylinder was used to measure the fuel removed during vehicle preparation for enhanced accuracy. Sterile 8 oz. glass sample containers were procured and pre-labeled. A line was scribed at the 75 ml level for filling the sample container to the proper sample level. Since these sample containers were sterile chemical laboratory quality, they were used in the as-received condition. New funnels were purchased for the program and labeled Fuel E and Fuel H. In Phase II, the glass containers were filled with the final sample fuel in case additional chemistry analytical information was requested.

C. VEHICLES

The test program was conducted on the five vehicles as specified by CRC and listed in Table 2. Only the Toyota Corolla and the Mitsubishi were retained and tested in Phase II. The vehicles for this program were manufactured in the 2000 model year except for the Chevrolet Cavalier which was a 1999 model. Vehicle tanks and lines were visually inspected for any damage during the vehicle preparation phase. No problems were found.

Table 2 – Test Vehicles

					Phase I – Flush Procedures		
	Model Year	Eng. Displ.	Tank Capac.*	Vehicle Identification Number	A	B	C
Ford Windstar	2000	3.8L	26.0 gal.	2FMZA5142YBB89386	1	1	1
Mitsubishi Galant	2000	2.4L	16.3 gal.	4A3AA46G41E141829	1	1	1
Chevrolet Cavalier	1999	2.2L	15.2 gal.	3G1JC5249X5815172	1	1	1
Nissan Maxima	2000	3.0L	18.5 gal.	JN1CA31DXYT543110	1	1	1
Toyota Corolla	2000	1.8L	13.2 gal.	1NXBR12E3YZ405041	2	1	1

* The fuel tank capacity was determined from an information search. It was not measured in this program.

D. VEHICLE PREPARATION

The test vehicles were parked in approximately the same position when Fuels E and H were drained to minimize tank angle variations that would change the amount of fuel that could be pumped from the tank. The test area was located outside, under an awning adjacent to the SwRI Automotive Fleet Laboratory. A ground rod was installed and tested for conductivity prior to the start of the program. The test fuel drums and the vehicles were properly grounded for safety during the program.

The Vehicle Preparation procedure was performed on each vehicle. The procedure is included in Appendix B. During the vehicle preparation the existing fuel was removed from the vehicle and the system residual fuel was measured. The *system residual fuel* is defined as the amount of fuel

that remains in the vehicle fuel system after a fuel drain procedure is conducted using the vehicle fuel pump.

Each vehicle's electrical system was studied and relay contact points, which would activate the vehicle fuel pump while the engine was not running, were located,. A jumper circuit was used to activate the vehicle fuel pump for draining the fuel. The Ford Windstar had a Schrader valve in the fuel feed line and it was used for the fuel drain procedure on that vehicle. For testing the Toyota Corolla, the Mitsubishi Galant, and the Chevrolet Cavalier, the connector between the fuel line and the rail was disconnected to make fuel drains and to procure fuel samples. The connection of the fuel rail to the fuel feed line was not readily accessible on the Nissan Maxima. Thus, a Schrader valve was installed in the fuel return line and an on-off valve was installed in the fuel return line downstream of the Schrader valve.

The *fuel drain procedure* is defined as the removal of the fuel from the vehicle fuel system using the vehicle fuel pump. The drain procedure used on this program should be typical of the methods used in CRC field studies. To enhance the repeatability of the drain procedure for this program, the operators were instructed to continue running the fuel pump until the they were sure the fuel pump would not pick up any more fuel in the tank.

In the vehicle preparation phase, a fuel drain procedure to remove the existing fuel was performed. The fuel tank was removed from the vehicle and then the remaining fuel removed by tipping the tank and using an external fuel pump. The fuel lines, fuel rail, and injectors were disconnected and the lines blown out with compressed nitrogen. The fuel tank, fuel lines, and injectors were reassembled into the vehicle. One gallon of Fuel H was added to the tank. The engine was cranked until it just began to run and then the ignition was turned to the off position. In cases when the vehicle would not start because the fuel level in the tank was below the fuel pump pickup point, fuel was added in 1000 ml increments until the engine would begin to run.

A second fuel drain procedure was then conducted using the vehicle fuel pump. The amount of fuel removed was measured in a graduated cylinder. The difference in the amount of fuel added to the empty fuel system and the amount removed is the system residual fuel volume. According

to the calculated predictions of the flush procedure results, the system residual fuel is a significant variable.

E. FLUSH PROCEDURES

In Phase I, flush procedures A, B, and C were performed per CRC specifications. When the results of Phase I had been reviewed, SwRI was asked to recommend new flush procedures and techniques that would potentially improve the flush effectiveness. After discussions with several CRC committee members, SwRI recommended the following enhancements:

1. Add more fuel to increase the dilution.
2. Drive the vehicles after adding fuel instead of conducting a 2-minute engine idle to ensure the fuel drained in the subsequent operation represented the average ethanol content in the vehicle fuel system. It was suspected that the fuel in the vehicle tank might be stratified, and fuel with lower than average ethanol content was being drained.

Phase 2 of the CRC Fuel Effectiveness Study was conducted on the Toyota Corolla and the Mitsubishi Galant. Flush procedures C modified, E, E modified, and F were conducted. An overview of all the flush procedures in the CRC Fuel Effectiveness Program is shown in Table 3. A more detailed table of the flush procedure definition is shown in Appendix C. The flush procedure checklists used by the SwRI Senior Technicians are included in Appendix D.

Table 3 – Flush Procedure Overview

	Flush Procedure						
	Phase I			**Phase II**			
Fuel Add	**A**	**B**	**C**	**C Mod.**	**E**	**E Mod.**	**F**
#1	2 gal.	1 gal.	2 gal.	2 gal.	4 gal.	4 gal.	8 gal.
Operation	Idle	Idle	Idle	10 mile	Idle	Idle *	Idle
#2	4 gal.**	1 gal.	2 gal.	2 gal.	4 gal.	4 gal.	4 gal.
Operation	-	Idle	Idle	10 mile	Idle	Idle *	Idle
#3	-	4 gal.**	4 gal.**	4 gal.**	4 gal.**	4 gal.**	4 gal.**
Operation	10 mile	10 mile	10 mile	10 mile	10 mile	10 mile	10 mile
Total Fuel	6 gal.	6 gal.	8 gal.	8 gal.	12 gal.	12 gal.	16 gal.

* During the 2-minute idle the vehicle was rocked from side to side for 15 seconds.
** The four-gallon fill is not part of the flushing procedure but rather the addition of fuel to begin a driveability test.

The vehicle fuel drain procedures were all accomplished with the same technique used in the vehicle preparation for that vehicle. Appropriately labeled calibrated cans were filled to the proper volume for adding fuel to the vehicles. The appropriately labeled funnels were installed into the vehicle filler necks when pouring fuel into the vehicle.

A vehicle route was developed to accumulate ten miles on the vehicles. The procedure is included in Appendix E. The mileage accumulation based on the odometers of the vehicles ranged from 9.8 to 10.4 miles. Due to the speed limit on the Southwest Research Institute campus and the traffic lights on the public roads outside the SwRI main gate, the average speeds for the mileage accumulation were less than 45 mph. Traffic density and traffic lights caused the speeds to vary from a minimum of 19.5 mph to a maximum of 40.4 mph. The arithmetic average of the speeds was 30.1 mph in Phase I and 31.1 mph in Phase II. Since the purpose of the mileage accumulation was to mix the fuel in the vehicle fuel system, the average speed for a ten-mile run is probably not significant to the flush procedure test.

The fuel samples were obtained into pre-labeled 8oz. sterile glass containers scribed at the 75ml level. Fuel was taken directly from the fuel line in the same manner as the fuel drains using the vehicle fuel pump to draw the fuel sample. A fuel sample was obtained by first drawing a purge sample into the sample container. Then the excess fuel greater than 75ml was poured back into the vehicle tank, retaining 75 ml in the sample container. In Phase II, the glass containers were filled with the final sample in case additional chemistry analytical information was requested. The samples were delivered to the SwRI Petroleum Research Department and each sample was analyzed for ethanol by volume percent using the ASTM D 5599 method.

IV. RESULTS

A. PHASE I

Phase I consisted of performing flush procedures A, B, and C on five vehicles. These evaluations were performed to the CRC specifications as prescribed in the original request for proposal. The results of the three flush procedures in Phase I on each vehicle are shown in Table 4. Sixteen flush procedure tests were conducted.

Table 4 – Phase I Test Results Summary

Vehicle Manufacturer	Toyota	Ford	Mitsubishi	Chevrolet	Nissan
Model	Corolla	Windstar	Galant	Cavalier	Maxima
System Residual Fuel (Gal.)	.23	1.04	1.41	0.92	1.02
Flush Procedure A					
Initial Ethanol (vol%)	9.78	7.62	7.08	7.61	7.82
Final Ethanol (vol%)	0.48	0.51	1.37	0.81	0.70
Flush Effectiveness	95.1%	93.3%	80.6%	89.4%	91.0%
Flush Procedure B					
Initial Ethanol (vol%)	8.36	7.93	6.76	7.08	7.43
Final Ethanol (vol%)	0.69	0.45	1.27	0.60	1.12
Flush Effectiveness	91.7%	94.3%	81.2%	91.5%	84.9%
Flush Procedure C					
Initial Ethanol (vol%)	8.49	7.75	6.71	7.09	7.86
Final Ethanol (vol%)	0.65	0.24	0.75	0.32	0.43
Flush Effectiveness	92.3%	96.9%	88.8%	95.5%	94.5%
Flush Procedure A (Rerun)					
Initial Ethanol (vol%)	8.57				
Final Ethanol (vol%)	0.60				
Flush Effectiveness	93.0%				

Volume percentages by ASTM D 5599

Note that the system residual fuel volumes for the Ford Windstar, the Mitsubishi Galant, and Nissan Maxima were greater than one gallon.

The Toyota Corolla flush procedure A was conducted twice. The Toyota vehicle preparation was conducted with Fuel E. Therefore, the first Flush Procedure A on the Toyota started with essentially 100% Fuel E in the vehicle. All the other flush procedures in the program, including the second Toyota Corolla flush procedure A test, commenced with the Fuel H from the vehicle preparation or the fuel from the previous flush procedure conducted on that vehicle.

B. PHASE II

Flush procedures C Modified, E, E modified, and F were developed to increase the flush effectiveness. The results are shown in Table 5.

Table 5 – Phase II Results Summary

Vehicle Manufacturer	Toyota	Ford	Mitsubishi	Chevrolet	Nissan
Model	Corolla	Windstar	Galant	Cavalier	Maxima
System Residual Fuel (Gal.)	0.23	1.04	1.41	0.92	1.02
Flush Procedure C Modified					
Initial Ethanol (vol%)	6.89		6.59		
Final Ethanol (vol%)	0.01		0.45		
Flush Effectiveness	99.9%		93.2%		
Flush Procedure E					
Initial Ethanol (vol%)	8.89		6.85		
Final Ethanol (vol%)	0.49		0.36		
Flush Effectiveness	94.5%		94.7%		
Flush Procedure E Modified					
Initial Ethanol (vol%)			6.84		
Final Ethanol (vol%)			0.21		
Flush Effectiveness			96.9%		
Flush Procedure F					
Initial Ethanol (vol%)	9.12		6.70		
Final Ethanol (vol%)	0.01		0.24		
Flush Effectiveness	99.9%		96.4%		

C. CALCULATED PREDICTIONS

For each flush procedure in each vehicle, the ethanol volume percentage was predicted using a calculation based on the system residual fuel of the vehicle and the ethanol volume percentage in the initial fuel sample. For these calculations the following assumptions were made:

1. The resulting volume of adding two blends together was equal to the arithmetic sum of the two volumes of the original blends.
2. Losses of fuel in the form of vapor through the evaporative canister and evaporative emission system were assumed to be zero.
3. During vehicle driving cycles and sample procurement the amount of ethanol removed from the vehicle system is proportional to the total concentration of ethanol in the vehicle system.

A sample calculation for the Chevrolet Cavalier Flush Procedure A is shown below. The numbers in parenthesis correspond with the flush procedure task numbers in Appendix C. The

system residual fuel (*SRF*) for the Chevrolet Cavalier was measured as 0.92 gallons. The volume percentage of ethanol in the initial fuel sample is 7.61%. The volume of ethanol (VE) in gallons in the vehicle fuel system by calculation after task #2 is:

VE(2) = [4 + SRF][7.61%] = 0.374 gallons

The volume of ethanol in the vehicle system after task #5 is calculated below. Note that the volume of fuel in the vehicle system after task #5 is the system residual fuel volume (0.92 gallons).

VE(5) = [0.374][SRF]/[4 + SRF] = 0.0699 gallons

The volume of ethanol in the system after task #6 is the same as the amount after task #5. Two gallons of Fuel H are added to the vehicle system, but Fuel H has no ethanol content. The total volume of fuel in the vehicle fuel system after task #6 is 2 gallons plus the system residual fuel volume (0.92 gallons), which equals 2.92 gallons. After task #11 there is again 0.92 gallons of fuel in the vehicle fuel system and the volume of ethanol is calculated below.

VE(11) = 0.0699[SRF]/[2 + SRF] = 0.022 gallons

After adding the 4 gallons of Fuel H in task #12, there are a total of 4.92 gallons of fuel in the vehicle system. However, the volume of ethanol is still 0.022 gallons. Thus, the volume percentage of ethanol based on this calculation is:

Ethanol (vol%) = 0.022/[4 + SRF] = 0.45%

In the same manner all the flush procedure test results were predicted by calculation. Please refer to Appendix F.

V. DISCUSSION

A. SUMMARY

Phase I provides CRC with an indication of the effectiveness of flush procedures A, B, and C in each of the vehicles tested. The reported results with the exception of flush procedure A in the

Toyota Corolla, are single point results. The statistical variation of the flush procedure evaluation test is not known. The results of Phase I raised two major questions:

1. What flush procedures and/or techniques could be employed to improve the flush effectiveness? The Mitsubishi Galant had the highest residual fuel volume (worst case for flush effectiveness) of 1.41 gallons. Starting with a fuel containing 6.59 volume percent ethanol, flush procedure C (theoretically the most effective procedure in Phase I) had a final fuel sample with 1.37 volume percent ethanol. The flush effectiveness was 80.6%. The Phase II goal was to develop a procedure to reduce the final sample ethanol volume percent.
2. The measured ethanol volume percent results were in the "order of magnitude range", but were generally higher (less fuel flush effectiveness) than the calculated results. The measured ethanol volume percent results of the Ford Windstar were the closest to the calculated results. The Toyota Corolla had the lowest residual fuel amount of 0.23 gallons. Theoretically, the fuel flushes with the Toyota Corolla for procedures A, B, and C should have been more efficient than the same procedure in the other vehicles. However, the flush procedure C result with the Toyota Corolla was the least effective with the exception of the Mitsubishi Galant. The Toyota had a flush procedure C measured result of 0.65 volume percent, but the predicted result by calculation was 0.0%. The question was, "Why was the measured fuel flush effectiveness worse than the calculated predictions?"

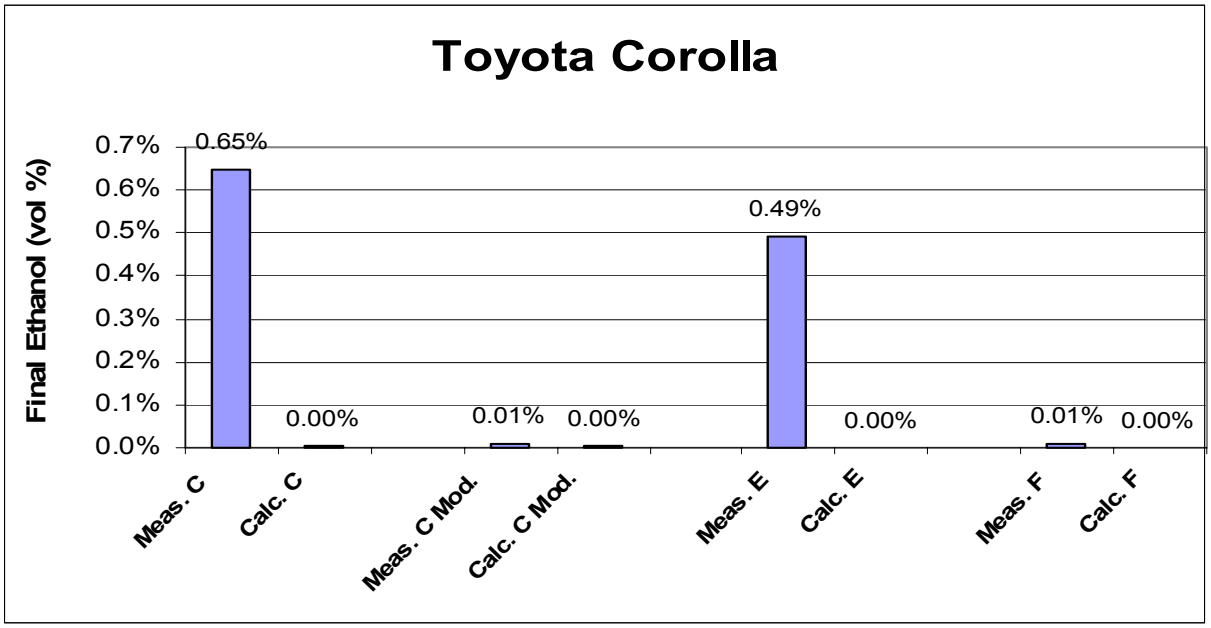
Phase II was conducted to answer the questions noted above. The following is a discussion of the findings of Phase II. All the results are displayed graphically in Appendix G.

1. Fuel flush effectiveness can be improved by adding more fuel, performing more complete fuel drains, or performing more fuel drains. The cost of the flush fuel is a concern, so it was a goal to minimize the amount of additional fuel required. The time to perform fuel drains and fuel additions is also a concern. It was decided the optimum means to improve the effectiveness was to add more fuel rather than add more drain procedures. Flush procedure E uses a total of 12 gallons of flush fuel and flush procedure F uses 16 gallons of flush fuel. Potentially a fuel drain procedure could be more efficient by removing more fuel or in essence reducing the system residual fuel amount. The fuel tank could be removed from the

vehicle and the fuel drained with an external pump. However, the time and facilities (example: vehicle hoist) were a concern with this technique. On some vehicles a small diameter hose could potentially be pushed through the filler neck and residual fuel could be drained with an external pump. However, the fuel tank configuration including the baffles on some vehicles would prohibit this technique. Therefore, it was not considered for Phase II.

A flush procedure D was discussed, which was the same as flush procedure A except more fuel was added after the first fuel drain. The amount of fuel required for a procedure D to equal the theoretical flush effectiveness of flush procedure E was significantly greater than the 12 gallons of fuel used in flush procedure E. In most cases the amount of fuel required in flush procedure D would have exceeded the fuel tank capacity. Therefore, flush procedure D was not conducted in Phase II.

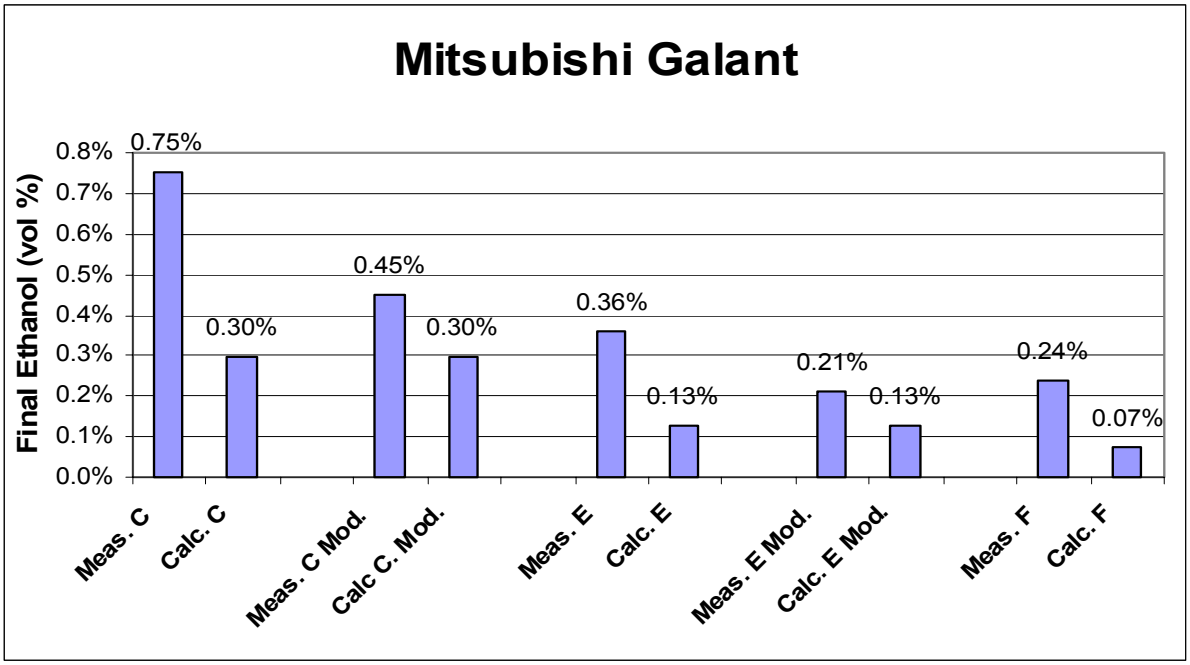
Figure 1 – Toyota Corolla Procedure C and Phase II Results



In Figures 1 and 2 note the decrease in the final ethanol volume percent from procedure C to procedure E and then further improvement with procedure F. With regards to procedures C, E, and F the measured result is not as low as the calculated prediction except the Toyota Corolla procedure F. In the case of the Toyota Corolla the predicted results for procedures C,

E, and F were less than 0.01% ethanol by volume based on the low relatively low residual fuel value. Procedure F measured result in the Toyota was 0.01%.

Figure 2 – Mitsubishi Galant Procedure C and Phase II Results



2. SwRI had the idea that the two minute idle step was not sufficient to completely mix the fuel in the tank after the fuel was added. Note there are two idle steps in flush procedures B, C, E and F. If the mixing was not complete, then the fuel removed in the next drain step might have less ethanol by volume percentage than the average of all the fuel in the vehicle system. It was theorized that this was a contributing factor to the disagreement of the predicted results and the measured results. The C modified flush procedure was developed to ensure complete mixing of the fuel in the vehicle system after adding flush fuel. In the C modified procedure the two minute idles were replaced by the ten mile driving procedure.

   Members of the CRC were concerned about the time and labor involved in performing the ten-mile drive procedures or even a potentially shorter procedure. The CRC directed SwRI to conduct a modified E flush procedure. In this procedure the vehicle is idled twice for 2 minutes. During each two minute idle step the rear-end of the vehicle is rocked from side to

side for 15 seconds. This operation was accomplished with one person on either side of the vehicle.

Refer to Figures 1 and 2. The C modified procedures conducted on the Toyota Corolla and the Mitsubishi Galant resulted in lower measured results than the comparable procedure C measured result. It is concluded that this is due to the mixing of the fuel in the fuel system during the ten-mile drives in the modified C procedures, which replaced the 2 minute idle steps. In the case of the C modified procedure conducted on the Toyota Corolla, the measured result was 0.01% ethanol by volume, which is essentially equal to the predicted result of 0.0%. The measured procedure E modified result on the Mitsubishi Galant was 0.21% which is less than the procedure E result but not as low as the predicted result of 0.13% ethanol by volume.

B. TEST VARIATION

Except for the repetition of Flush Procedure A in the Toyota Corolla all the flush effectiveness tests were single point data. This section is a discussion of a few items that would affect the test variability. The amount of fuel removed in a drain procedure is a variable. With the Nissan Maxima parked in the same spot, a short repeatability study with the same operator was performed. The fuel drained into the graduated cylinder was poured into the tank and measured three times. The amount of fuel removed for each trial is listed in Table 6.

Table 6 – Drain Procedure Repeatability

Trial Number	Amount of Fuel Removed
1	1060 ml
2	1020 ml
3	1025 ml

Based on this data, the repeatability of the drain procedure appears to be good. However, in practice, tank angle could cause variation. The last 400-500 ml drained very slowly. Often the fuel stream was temporarily reduced to droplets before the pump would pick up more fuel. A different technician may have decided to discontinue the fuel drain procedure with the residual

fuel amount plus 400-500 ml of fuel left in the vehicle system. This would have an adverse affect on the reproducibility.

To determine the system residual fuel volume the technicians removed as much of the fuel from the vehicle fuel system as possible before adding a known quantity of Fuel H. Some amount of fuel may have been inadvertently left in the tank or the fuel lines.

The ASTM D 5599 test method has a published reproducibility for ethanol by weight percent value based on the true value of the sample. This is also a source of variation as shown below in both the initial sample and the final sample of a flush test procedure.

Table 7 – D 5599 Reproducibility

Component Weight Percent	Reproducibility
0.20%	0.07%
0.50%	0.16%
1.00%	0.27%
5.00%	0.98%
10.00%	1.70%

VI. CONCLUSIONS

1. The residual fuel left in the system after draining is a major factor affecting fuel flushing effectiveness.
2. It is important to allow the vehicle fuel pump to continue to run when performing the draining operation until no more fuel can be drained.
3. During the flushing procedure, the tank needs to be agitated after each fuel loading to ensure that the residual fuel is mixed with the incoming charge to improve the flushing efficiency.
4. Flushing Procedure E Modified provided the best flushing efficiency at minimum flushing fuel addition.
5. A calculation method was developed to predict the theoretical flushing efficiency, which assisted in assessing and understanding the various flushing procedures.

APPENDIX A – PHOTOGRAPHS

Calibrated Cans

55-gallon drum of Fuel E
with a hand pump installed

APPENDIX B – VEHICLE PREPARATION DATA SHEET

Vehicle Preparation

Vehicle Make_____

Vehicle Number_____

Date_____

Change Note:

1. ***The Vehicle Preparation has been modified to use Fuel H.***
2. ***When draining the vehicle fuel tank, leave the fuel pump on until only drops are coming out of the line. This will ensure that each vehicle fuel tank drain is complete, and the same as the other fuel tank drains.***

1._____ Ground the fuel rail or adapter fitting to a waste fuel can. The fuel will be drained through the Schrader or adapter fitting using the fuel pump.

1A._____If there is no Schrader valve, a temporary test fitting will have to be fabricated and installed between the fuel feed line and the injector fuel rail.

2._____ The vehicle fuel tank will be grounded to the ground rod mounted near the outside hoist. The vehicle fuel tank will be physically removed from the vehicle and disassembled. Any fuel remaining in the vehicle tank will be poured out into a fuel waste storage tank.

3._____ The vehicle tank will receive a flush of Fuel H. Use approximately 1 gallon of Fuel H and "slosh" around in the tank. The Fuel H will be poured into a waste storage tank and the vehicle tank will then be allowed to air dry. ***Use a ball and syringe and/or red rags to remove as much fuel as possible.***

4._____ The fuel lines, injectors, fuel filter, and rails will be disassembled at each end and blown out with compressed nitrogen. Per Jack Ballard, do not use shop air.

5._____ The fuel system will be reassembled into the vehicle. A new fuel filter is not required. At this point the fuel system should be essentially empty.

6._____ Exactly one gallon of Fuel H will be added to the vehicle using the dedicated calibrated can for Fuel H. This volume measurement is very critical.

7._____ The vehicle ignition will be engaged and turned off when the engine begins to start.

8._____ The vehicle fuel tank will be drained through the Schrader valve using the vehicle fuel pump. The drained fuel will be contained in the calibrated can and the volume measured. This volume measurement is very critical.

Record the measured volume of fuel._____

APPENDIX C – DETAILED OUTLINE OF THE FLUSH PROCEDURES

Detailed Outline of the Flushing Procedures

	Description of the Task	Flush Procedure A	Flush Procedure B	Flush Procedure C	Flush Procedure C Modified	Flush Procedure E	Flush Procedure E Modified	Flush Procedure F
1	Perform fuel drain procedure	Done in Veh. Prep.	Fuel left after Proc. A	Fuel left after Proc. B	Fuel left after prev. test	Fuel left after prev. test	Fuel left after prev. test	Fuel left after prev. test
2	Add Fuel E to the tank	4 gallons	4 gallons	4 gallons	4 gallons	4 gallons	4 gallons	4 gallons
3	Vehicle mileage accumulation	10 miles	10 miles	10 miles	10 miles	10 miles	10 miles	10 miles
4	Take a fuel sample	75 ml	75 ml	75 ml	75 ml	75 ml	75 ml	75 ml
5	Perform fuel drain procedure	*	*	*	*	*	*	*
6	Add Fuel H to the tank	2 gallons	1 gallon	2 gallons	2 gallons	4 gallons	4 gallons	8 gallons
7	Run the vehicle	2 min. idle	2 min. idle	2 min. idle	10 miles	2 min. idle	2 min. idle **	2 min. idle
8	Perform fuel drain procedure	Not Reqd.	*	*	*	*	*	*
9	Add Fuel H to the tank	Not Reqd.	1 gallon	2 gallons	2 gallons	4 gallons	4 gallons	4 gallons
10	Run the vehicle at idle	Not Reqd.	2 minutes	2 minutes	10 miles	2 min. idle	2 min. idle **	2 min. idle
11	Perform fuel drain procedure	*	*	*	*	*	*	*
12	Add Fuel H to the tank	4 gallons	4 gallons	4 gallons	4 gallons	4 gallons	4 gallons	4 gallons
13	Vehicle mile accumulation	10 miles	10 miles	10 miles	10 miles	10 miles	10 miles	10 miles
14	Take a fuel sample	75 ml	75 ml	75 ml	8 oz.	8 oz.	8 oz.	8 oz.

* The amount of fuel drained from the vehicle is equal to the volume of fuel in the fuel system at the start of the drain procedure minus the system residual fuel amount.

** During the 2 minute idle, the rear end of the vehicle was rocked back on forth to agitate the fuel tank and mix the fuel.

APPENDIX D – FLUSH PROCEDURE DATA SHEETS

First Flush Procedure A

Vehicle Make_____

Vehicle Number_____

Date_____

Change note:

1. ***After each fuel drain and fuel sample procurement task, reinstall the fuel rail fitting, start the engine, and check to ensure there are no leaks.***
2. ***When draining the vehicle fuel tank, leave the fuel pump on until only drops are coming out of the line. This will ensure that each vehicle fuel tank drain is complete, and the same as the other fuel tank drains.***

1._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.

1A._____Using the funnel labeled Fuel E, pour the fuel from the calibrated can into the fuel tank.

2._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.

2A._____Using the funnel labeled Fuel E, pour the fuel from the calibrated can into the fuel tank.

Steps 1 through 2A make a total of four gallons.

3._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

4._____ Use the vehicle fuel pump to draw the fuel sample. Use a pre-labeled 8 oz. sterile sample container. A fuel sample will be obtained by drawing a purge sample into the sample container. Pour fuel back into the vehicle tank, retaining 75 ml in the sample container. The sample container will be scribed at the 75 ml level.

5._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

6._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or adapter fitting.

7._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

8._____ Ground the two gallon calibrated fuel can labeled Fuel H to nozzle from the Fuel H pump dispenser. Add two gallons of Fuel H to the calibrated can.

9._____ Using the dedicated Fuel H funnel pour the fuel from the calibrated can into the vehicle fuel tank.

10._____ Idle the vehicle for 2 minutes.

11._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

12._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

13._____ Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.

13A._____Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.
A total of 4 gallons should have been added to the vehicle in steps 13 and 13A.

14._____The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

15._____ Use the vehicle fuel pump to draw the fuel sample. Use a pre-labeled 8 oz. sterile sample container. A fuel sample will be obtained by drawing a purge sample into the sample container. Pour fuel back into the vehicle tank, retaining 75 ml in the sample container. The sample container will be scribed at the 75ml level.

16._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

17._____ If the residual amount of ethanol is not at an acceptable low level to begin the next test based on the results, an additional fill and drain will be executed. The maximum acceptable level will be agreed upon with the CRC prior to starting the program.

Flush Procedure B

Vehicle Make_____

Vehicle Number_____

Date_____

Change note:

1. *After each fuel drain and fuel sample procurement task, reinstall the fuel rail fitting, start the engine, and check to ensure there are no leaks.*
2. ***When draining the vehicle fuel tank, leave the fuel pump on until only drops are coming out of the line. This will ensure that each vehicle fuel tank drain is complete, and the same as the other fuel tank drains.***

1._____ Using a UL approved ground strap, ground a fuel waste tank to the fuel injector rail or fuel line fitting.

2._____ Drain the fuel tank through the Schrader valve or adapter fitting using the vehicle fuel pump. Use the hose for draining labeled Fuel H.

3._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel pour the fuel from the calibrated can into the fuel tank.

4._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel pour the fuel from the calibrated can into the fuel tank.
In Steps 3 through 4, a total of four gallons should be added to the vehicle.

5._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

6._____ Use the vehicle fuel pump to draw the fuel sample. Use a pre-labeled 8 oz. sterile sample container. A fuel sample will be obtained by drawing a purge sample into the sample container. Pour fuel back into the vehicle tank, retaining 75 ml in the sample container. The sample container will be scribed at the 75 ml level.

7._____Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

8._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

9._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

10._____Ground the one gallon calibrated can labeled Fuel H to the nozzle from the Fuel H drum dispenser. Add one gallon of Fuel H to the calibrated can.

11._____ Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

12._____ Idle the vehicle for 2 minutes.

13._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

14._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

15._____ Ground the one gallon calibrated can labeled Fuel H to the nozzle from the Fuel H drum dispenser. Add one gallon of Fuel H to the calibrated can.

16._____ Using the Fuel H dedicated funnel pour the fuel from the calibrated can into the vehicle fuel tank.

17._____ Idle the vehicle for 2 minutes.

18._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

19._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

20._____ Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.

20A._____Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel pour the contents into the vehicle tank.
A total of 4 gallons should have been added to the vehicle in steps 20 and 20A.

21._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

22._____ Use the vehicle fuel pump to draw the fuel sample. Use a pre-labeled 8 oz. sterile sample container. A fuel sample will be obtained by drawing a purge sample into the sample container. Pour fuel back into the vehicle tank, retaining 75 ml in the sample container. The sample container will be scribed at the 75 ml level.

23._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

24._____ If the residual amount of ethanol is not at an acceptable low level to begin the next test based on the results, an additional fill and drain will be executed. The maximum acceptable level will be agreed upon with the CRC prior to starting the program.

Procedure C

Vehicle Make_____

Vehicle Number_____

Date_____

Change note:

1. ***After each fuel drain and fuel sample procurement task, reinstall the fuel rail fitting, start the engine, and check to ensure there are no leaks.***
2. ***When draining the vehicle fuel tank, leave the fuel pump on until only drops are coming out of the line. This will ensure that each vehicle fuel tank drain is complete, and the same as the other fuel tank drains.***

1._____Using a UL approved ground strap, ground a fuel waste tank to the fuel injector rail or fuel line fitting.

2._____ Drain the fuel tank through the Schrader valve or adapter fitting using the vehicle fuel pump. Use the hose for draining labeled Fuel H.

3._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel, pour the fuel from the calibrated can into the fuel tank.

4._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel, pour the fuel from the calibrated can into the fuel tank.
In Steps 3 through 4 a total of four gallons should be added to the vehicle

5._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

6._____ Use the vehicle fuel pump to draw the fuel sample. Use a pre-labeled 8 oz. sterile sample container. A fuel sample will be obtained by drawing a purge sample into the sample container. Pour fuel back into the vehicle tank, retaining 75 ml in the sample container. The sample container will be scribed at the 75 ml level.

7._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

8._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

9._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

10._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

11._____ Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

12._____ Idle the vehicle for 2 minutes.

13._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

14._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

15._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

16._____ Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

17._____ Idle the vehicle for 2 minutes.

18._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line adapter.

19._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

20._____ Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.

20A._____Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.
A total of 4 gallons should have been added to the vehicle in steps 20 and 20A.

21._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

22._____ Use the vehicle fuel pump to draw the fuel sample. Use a pre-labeled 8 oz. sterile sample container. A fuel sample will be obtained by drawing a purge sample into the sample container. Pour fuel back into the vehicle tank, retaining 75 ml in the sample container. The sample container will be scribed at the 75 ml level.

23._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

24._____ If the residual amount of ethanol is not at an acceptable low level to begin the next test based on the results, an additional fill and drain will be executed. The maximum acceptable level will be agreed upon with the CRC prior to starting the program.

Procedure C Modified

Vehicle Make_____

Vehicle Number_____

Date_____

Change note:

1. ***After each fuel drain and fuel sample procurement task, reinstall the fuel rail fitting, start the engine, and check to ensure there are no leaks.***
2. ***When draining the vehicle fuel tank, leave the fuel pump on until only drops are coming out of the line. This will ensure that each vehicle fuel tank drain is complete, and the same as the other fuel tank drains.***
3. ***Replace the two idle steps with the ten-mile drive procedure.***

1._____ Using a UL approved ground strap, ground a fuel waste tank to the fuel injector rail or fuel line fitting.

2._____ Drain the fuel tank through the Schrader valve or adapter fitting using the vehicle fuel pump. Use the hose for draining labeled Fuel H.

3._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel, pour the fuel from the calibrated can into the fuel tank.

4._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel, pour the fuel from the calibrated can into the fuel tank.
In Steps 3 through 4 a total of four gallons should be added to the vehicle

5._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

6._____ ***Use the vehicle fuel pump to draw the fuel sample. Use a new unlabeled 8 oz. sterile sample container. A fuel sample will be obtained by first drawing a full 8 oz. purge sample into the sample container. Pour fuel back into the vehicle tank.***

6A._____ ***Use a new labeled 8 oz. sterile jar. Draw 75 ml in the sample container. The sample container will be scribed at the 75 ml level.***

7._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

8._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

9._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

10._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

11._____ Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

12._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

13._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

14._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

15._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

16._____ Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

17._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

18._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line adapter.

19._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

20._____ Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.

20A._____Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.
A total of 4 gallons should have been added to the vehicle in steps 20 and 20A.

21._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

22._____ ***Use the vehicle fuel pump to draw the fuel sample. Use a new hose to direct fuel to the sample container. Use a new unlabeled 8 oz. sterile sample container. A fuel sample will***

be obtained by drawing a full 8 oz. purge sample into the sample container. Pour fuel back into the vehicle tank.

22A._____***Use a new labeled 8 oz. sterile jar. Fill the sample container.***

23._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

24._____ If the residual amount of ethanol is not at an acceptable low level to begin the next test based on the results, an additional fill and drain will be executed. The maximum acceptable level will be agreed upon with the CRC prior to starting the program.

Procedure E

Vehicle Make_____

Vehicle Number_____

Date_____

Change note:

1. ***After each fuel drain and fuel sample procurement task, reinstall the fuel rail fitting, start the engine, and check to ensure there are no leaks.***
2. ***When draining the vehicle fuel tank, leave the fuel pump on until only drops are coming out of the line. This will ensure that each vehicle fuel tank drain is complete, and the same as the other fuel tank drains.***
3. ***When taking fuel samples return one full 8 oz. purge sample into the tank before taking the sample.***

1._____ Using a UL approved ground strap, ground a fuel waste tank to the fuel injector rail or fuel line fitting.

2._____ Drain the fuel tank through the Schrader valve or adapter fitting using the vehicle fuel pump. Use the hose for draining labeled Fuel H.

3._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel, pour the fuel from the calibrated can into the fuel tank.

4._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel, pour the fuel from the calibrated can into the fuel tank.
In Steps 3 through 4 a total of four gallons should be added to the vehicle

5._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

6._____ ***Use the vehicle fuel pump to draw the fuel sample. Use a new unlabeled 8 oz. sterile sample container. A fuel sample will be obtained by first drawing a full 8 oz. purge sample into the sample container. Pour fuel back into the vehicle tank.***

6A._____ ***Use a new labeled 8 oz. sterile jar. Draw 75 ml in the sample container. The sample container will be scribed at the 75 ml level.***

7._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

8._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

9._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

10._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

10A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

11._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

11A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

A total of 4 gallons of Fuel H will be added in steps 10 through 11A.

12._____ Idle the vehicle for 2 minutes.

13._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

14._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

15._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

15A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

16._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

16A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

A total of 4 gallons of Fuel H will be added in steps 15 through 16A.

17._____ Idle the vehicle for 2 minutes.

18._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line adapter.

19._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

20._____ Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.

20A._____Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.
A total of 4 gallons should have been added to the vehicle in steps 20 and 20A.

21._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

22._____ ***Use the vehicle fuel pump to draw the fuel sample. Use a new hose to direct fuel to the sample container. Use a new unlabeled 8 oz. sterile sample container. A fuel sample will be obtained by drawing a full 8 oz. purge sample into the sample container. Pour fuel back into the vehicle tank.***

22A._____***Use a new labeled 8 oz. sterile jar. Fill the sample container.***

23._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

Procedure E Modified

Vehicle Make_____

Vehicle Number_____

Date_____

Change note:

1. ***After each fuel drain and fuel sample procurement task, reinstall the fuel rail fitting, start the engine, and check to ensure there are no leaks.***
2. ***When draining the vehicle fuel tank, leave the fuel pump on until only drops are coming out of the line. This will ensure that each vehicle fuel tank drain is complete, and the same as the other fuel tank drains.***
3. ***When taking fuel samples return one full 8 oz. purge sample into the tank before taking the sample***
4. ***During the 2 minute idle periods, rock the vehicle back and forth for 15 seconds to promote mixing in the fuel tank.***

1._____ Using a UL approved ground strap, ground a fuel waste tank to the fuel injector rail or fuel line fitting.

2._____ Drain the fuel tank through the Schrader valve or adapter fitting using the vehicle fuel pump. Use the hose for draining labeled Fuel H.

3._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel, pour the fuel from the calibrated can into the fuel tank.

4._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel, pour the fuel from the calibrated can into the fuel tank.
In Steps 3 through 4 a total of four gallons should be added to the vehicle

5._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

6._____ ***Use the vehicle fuel pump to draw the fuel sample. Use a new unlabeled 8 oz. sterile sample container. A fuel sample will be obtained by first drawing a full 8 oz. purge sample into the sample container. Pour fuel back into the vehicle tank.***

6A._____ ***Use a new labeled 8 oz. sterile jar. Draw 75 ml in the sample container. The sample container will be scribed at the 75 ml level.***

7._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

8._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

9._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

10._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

10A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

11._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

11A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

A total of 4 gallons of Fuel H will be added in steps 10 through 11A.

12._____ Idle the vehicle for a total of 2 minutes. ***From approximately 15 seconds into the idle for a period of 15 seconds, rock the rear end of the vehicle from side to side. This task will require one person on each side of the vehicle.***

13._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

14._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

15._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

15A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

16._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

16A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

A total of 4 gallons of Fuel H will be added in steps 15 through 16A.

17._____ Idle the vehicle for 2 minutes. ***From approximately 15 seconds into the idle for a period of 15 seconds, rock the rear end of the vehicle from side to side. This task will require one person on each side of the vehicle.***

18._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line adapter.

19._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

20._____ Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.

20A._____Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.
Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.
A total of 4 gallons should have been added to the vehicle in steps 20 and 20A.

21._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

22._____ ***Use the vehicle fuel pump to draw the fuel sample. Use a new hose to direct fuel to the sample container. Use a new unlabeled 8 oz. sterile sample container. A fuel sample will be obtained by drawing a full 8 oz. purge sample into the sample container. Pour fuel back into the vehicle tank.***

22A._____***Use a new labeled 8 oz. sterile jar. Fill the sample container.***

23._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

Procedure F

Vehicle Make_____

Vehicle Number_____

Date_____

Change note:

1. ***After each fuel drain and fuel sample procurement task, reinstall the fuel rail fitting, start the engine, and check to ensure there are no leaks.***
2. ***When draining the vehicle fuel tank, leave the fuel pump on until only drops are coming out of the line. This will ensure that each vehicle fuel tank drain is complete, and the same as the other fuel tank drains.***
3. ***When taking fuel samples return one full 8 oz. purge sample into the tank before taking the sample.***

1._____ Using a UL approved ground strap, ground a fuel waste tank to the fuel injector rail or fuel line fitting.

2._____ Drain the fuel tank through the Schrader valve or adapter fitting using the vehicle fuel pump. Use the hose for draining labeled Fuel H.

3._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel, pour the fuel from the calibrated can into the fuel tank.

4._____ Ground the two gallon calibrated can labeled Fuel E to a fuel drum labeled Fuel E in the drum storage area. Add two gallons of Fuel E to the calibrated can.
Using the dedicated Fuel E funnel, pour the fuel from the calibrated can into the fuel tank.
In Steps 3 through 4 a total of four gallons should be added to the vehicle

5._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

6._____ ***Use the vehicle fuel pump to draw the fuel sample. Use a new unlabeled 8 oz. sterile sample container. A fuel sample will be obtained by first drawing a full 8 oz. purge sample into the sample container. Pour fuel back into the vehicle tank.***

6A._____ ***Use a new labeled 8 oz. sterile jar. Draw 75 ml in the sample container. The sample container will be scribed at the 75 ml level.***

7._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

8._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

9._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

10._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

10A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

10B._____Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

10C._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

11._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

11A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

11B._____Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

11C._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

A total of 8 gallons of Fuel H will be added in steps 10 through 11C.

12._____ Idle the vehicle for 2 minutes.

13._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line fitting.

14._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

15._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

15A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

16._____ Ground the two gallon calibrated can labeled Fuel H to the barrel labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

16A._____Using the dedicated Fuel H funnel, pour the fuel from the calibrated can into the vehicle fuel tank.

A total of 4 gallons of Fuel H will be added in steps 15 through 16A.

17._____ Idle the vehicle for 2 minutes.

18._____ Using an approved electrical ground strap, ground a fuel waste can to the fuel injector rail or fuel line adapter.

19._____ Drain the fuel tank through the Schrader valve or line fitting using the vehicle fuel pump.

20._____ Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.

20A._____Ground the two gallon calibrated can labeled Fuel H to a fuel drum labeled Fuel H in the drum storage area. Add two gallons of Fuel H to the calibrated can.

Using the dedicated Fuel H funnel, pour the contents into the vehicle tank.

A total of 4 gallons should have been added to the vehicle in steps 20 and 20A.

21._____ The vehicle will be operated on the public road system for ten miles at an average speed of 45-55 MPH. Use the CRC Route Procedure data sheet.

22._____ ***Use the vehicle fuel pump to draw the fuel sample. Use a new hose to direct fuel to the sample container. Use a new unlabeled 8 oz. sterile sample container. A fuel sample will be obtained by drawing a full 8 oz. purge sample into the sample container. Pour fuel back into the vehicle tank.***

22A._____***Use a new labeled 8 oz. sterile jar. Fill the sample container.***

23._____ Deliver the fuel sample to the SwRI Petroleum Products Research Department, Building 171, Room B136, for log in. One D 5599 analytical evaluation will be performed on the sample.

APPENDIX E - VEHICLE DRIVING CYCLE

CRC Route Procedure Data Sheet

Vehicle Make_____

Vehicle Number_____

Date_____

Drive the speed limit if traffic allows.

1. Record the starting odometer. _____
2. Record the start time. _____
3. If the vehicle has a trip odometer, set it to zero.
4. Proceed to Harold Vagtborg Avenue and turn right.
5. Turn right on Martin Goland Avenue (0.2 miles).
6. Turn left onto Tom Slick Avenue (0.3 miles).
7. Turn left at Culebra Road (0.9 miles).
8. Proceed under the 410 bridge and turn left onto the 410 service drive (2.2 miles).
9. Veer left onto the South 410 entrance ramp.
10. Exit 410 at the Marbach exit and proceed on the service drive to Marbach Road.
11. Turn left at the Marbach – 410 bridge and proceed north on the 410 service drive (5.0 miles).
12. Veer left onto the North 410 entrance ramp.
13. Return to Building 58 by the same route.
14. Record time. _____
15. Record odometer reading. _____
16. Record trip odometer reading. _____

CRC Vehicle Fuel Tank Flush Effectiveness Study

Mileage Accumulation Data

Performed by Southwest Research Institute

16-Apr-01

Summary of Data

Number of 10 Mile Drives	32
Overall Average Speed (mph)	30.1
Minimum Average Speed (mph)	19.5
Maximum Average Speed (mph)	40.4

Vehicle Manufacturer	Toyota		Ford		Mitsubishi		Chevrolet		Nissan	
Model	Corolla		Windstar		Galant		Cavalier		Maxima	
	First 10 Miles	Second 10 Miles	First 10 Miles	Second 10 Miles	First 10 Miles	Second 10 Miles	First 10 Miles	Second 10 Miles	First 10 Miles	Second 10 Miles
Fuel Flush Procedure A										
Date	3/29/01	3/29/01	4/4/01	4/5/01	4/9/01	4/9/01	4/2/01	4/2/01	4/12/01	4/12/01
Mileage by odometer	10.3	10.4	9.8	9.8	10.2	10.2	10.2	10.1	10.2	10.2
Time to drive the route (min.)	22	32	22	20	22	19	20	28	20	20
Average speed (mph)	28.1	19.5	26.7	29.4	27.8	32.2	30.6	21.6	30.6	30.6
Fuel Flush Procedure B										
Date	3/30/01	3/30/01	4/8/01	4/8/01	4/10/01	4/10/01	4/3/01	4/3/01	4/12/01	4/12/01
Mileage by odometer	10.3	10.3	9.8	9.8	10.3	10.3	10.2	10.2	10.1	10.1
Time to drive the route (min.)	18	19	18	20	17	19	22	21	20	15
Average speed (mph)	34.3	32.5	32.7	29.4	36.4	32.5	27.8	29.1	30.3	40.4
Fuel Flush Procedure C										
Date	3/30/01	3/30/01	4/8/01	4/9/01	4/10/01	4/10/01	4/4/01	4/4/01	4/12/01	4/12/01
Mileage by odometer	10.3	10.3	9.8	9.8	10.3	10.3	10.3	10.2	10.1	10.1
Time to drive the route (min.)	19	20	19	20	20	18	23	23	15	20
Average speed (mph)	32.5	30.9	30.9	29.4	30.9	34.3	26.9	26.6	40.4	30.3

CRC Vehicle Fuel Tank Flush Effectiveness Study
Phase II - Mileage Accumulation Data

Performed by Southwest Research Institute

25-May-01

Summary of Data

Number of 10 Mile Drives	18
Overall Average Speed (mph)	31.1
Minimum Average Speed (mph)	24.7
Maximum Average Speed (mph)	34.3

Vehicle Manufacturer	Toyota				Mitsubishi			
Model	Corolla				Galant			
	First 10 Miles	**Second 10 Miles**	**Third 10 Miles**	**Fourth 10 Miles**	**First 10 Miles**	**Second 10 Miles**	**Third 10 Miles**	**Fourth 10 Miles**
Fuel Flush Procedure C Modified								
Date	5/10/01	5/10/01	5/10/01	5/10/01	5/7/01	5/7/01	5/7/01	5/7/01
Mileage by odometer	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
Time to drive the route (min.)	19	19	18	25	20	19	19	21
Average speed (mph)	32.5	32.5	34.3	24.7	30.9	32.5	32.5	29.4
Fuel Flush Procedure E								
Date	5/9/01	5/9/01			5/3/01	5/3/01		
Mileage by odometer	10.3	10.3			10.3	10.3		
Time to drive the route (min.)	20	19			20	20		
Average speed (mph)	30.9	32.5			30.9	30.9		
Fuel Flush Procedure E Modified								
Date					5/11/01	5/11/01		
Mileage by odometer					10.3	10.3		
Time to drive the route (min.)					21	20		
Average speed (mph)					29.4	30.9		
Fuel Flush Procedure F Modified								
Date	5/9/01	5/9/01			5/3/01	5/3/01		
Mileage by odometer	10.3	10.3			10.3	10.3		
Time to drive the route (min.)	19	21			18	20		
Average speed (mph)	32.5	29.4			34.3	30.9		

APPENDIX F – CALCULATED PREDICTIONS OF THE RESULTS

Prediction of the Results based on Calculations

Performed by Southwest Research Institute

Vehicle Manufacturer	Toyota		Ford		Mitsubishi		Chevrolet		Nissan	
Model	Corolla		Windstar		Galant		Cavalier		Maxima	
System Residual Fuel (gal)	0.23		1.04		1.41		0.92		*0.99*	
	Total Fuel in Vehicle (gallons)	Ethanol in Fuel (gallons)	Total Fuel in Vehicle (gallons)	Ethanol in Fuel (gallons)	Total Fuel in Vehicle (gallons)	Ethanol in Fuel (gallons)	Total Fuel in Vehicle (gallons)	Ethanol in Fuel (gallons)	Total Fuel in Vehicle (gallons)	Ethanol in Fuel (gallons)
Procedure A - Phase I										
Initial Sample Ethanol Volume	9.78%		7.74%		7.08%		7.61%		7.82%	
Fill Tank 4 gallons Fuel E	4.23	0.414	5.04	0.39	5.41	0.383	4.92	0.374	4.99	0.39
Drain Vehicle	0.23	0.023	1.04	0.08	1.41	0.1	0.92	0.07	0.99	0.077
Fill with 2 gallons Fuel H	2.23	0.023	3.04	0.08	3.41	0.1	2.92	0.07	2.99	0.077
Drain Vehicle	0.23	0.002	1.04	0.027	1.41	0.041	0.92	0.022	0.99	0.025
Fill with 4 gallons Fuel H	4.23	0.002	5.04	0.027	5.41	0.041	4.92	0.022	4.99	0.025
Percent Ethanol by Calculation	0.05%		0.54%		0.76%		0.45%		0.50%	
Effectiveness by Calculation	99.5%		93.1%		89.3%		94.1%		93.6%	
Procedure B - Phase I										
Initial Sample Ethanol Volume	8.36%		7.93%		6.76%		7.08%		7.43%	
Fill Tank 4 gallons Fuel E	4.23	0.354	5.04	0.4	5.41	0.366	4.92	0.348	4.99	0.371
Drain Vehicle	0.23	0.019	1.04	0.083	1.41	0.095	0.92	0.065	0.99	0.074
Fill with 1 gallons Fuel H	1.23	0.019	2.04	0.083	2.41	0.095	1.92	0.065	1.99	0.074
Drain Vehicle	0.23	0.004	1.04	0.042	1.41	0.056	0.92	0.031	0.99	0.037
Fill with 1 gallons Fuel H	1.23	0.004	2.04	0.042	2.41	0.056	1.92	0.031	1.99	0.037
Drain Vehicle	0.23	0.001	1.04	0.021	1.41	0.033	0.92	0.015	0.99	0.018
Fill with 4 gallons Fuel H	4.23	0.001	5.04	0.021	5.41	0.033	4.92	0.015	4.99	0.018
Percent Ethanol by Calculation	0.02%		0.42%		0.61%		0.30%		0.36%	
Effectiveness by Calculation	99.7%		94.7%		91.0%		95.7%		95.1%	
Procedure C - Phase I										
Initial Sample Ethanol Volume	8.49%		7.75%		6.71%		7.09%		7.86%	
Fill Tank 4 gallons Fuel E	4.23	0.359	5.04	0.391	5.41	0.363	4.92	0.349	4.99	0.392
Drain Vehicle	0.23	0.0195	1.04	0.081	1.41	0.095	0.92	0.065	0.99	0.078
Fill with 2 gallons Fuel H	2.23	0.0195	3.04	0.081	3.41	0.095	2.92	0.065	2.99	0.078
Drain Vehicle	0.23	0.002	1.04	0.028	1.41	0.039	0.92	0.02	0.99	0.026
Fill with 2 gallons Fuel H	2.23	0.002	3.04	0.028	3.41	0.039	2.92	0.02	2.99	0.026
Drain Vehicle	0.23	0.0002	1.04	0.01	1.41	0.016	0.92	0.006	0.99	0.009
Fill with 4 gallons Fuel H	4.23	0.0002	5.04	0.01	5.41	0.016	4.92	0.006	4.99	0.009
Percent Ethanol by Calculation	0.00%		0.20%		0.30%		0.12%		0.18%	
Effectiveness by Calculation	99.9%		97.4%		95.6%		98.3%		97.7%	

Prediction of the Results based on Calculations

Performed by Southwest Research Institute

Vehicle Manufacturer	**Toyota**			**Mitsubishi**	
Model	**Corolla**			**Galant**	
System Residual Fuel (gal)	0.23			1.41	
	Total Fuel in Vehicle (gallons)	Ethanol in Fuel (gallons)		Total Fuel in Vehicle (gallons)	Ethanol in Fuel (gallons)

Procedure A (Rerun) - Phase I

Initial Sample Ethanol Volume	8.57%	
Fill Tank 4 gallons Fuel E	4.23	0.363
Drain Vehicle	0.23	0.02
Fill with 2 gallons Fuel H	2.23	0.02
Drain Vehicle	0.23	0.002
Fill with 4 gallons Fuel H	4.23	0.002
Percent Ethanol by Calculation	0.05%	
Effectiveness by Calculation	99.4%	

Procedure C Modified - Phase II

Initial Sample Ethanol Volume	8.69%		6.59%	
Fill Tank 4 gallons Fuel E	4.23	0.368	5.41	0.357
Drain Vehicle	0.23	0.02	1.41	0.093
Fill with 2 gallons Fuel H	2.23	0.02	3.41	0.093
Drain Vehicle	0.23	0.0021	1.41	0.038
Fill with 2 gallons Fuel H	2.23	0.0021	3.41	0.038
Drain Vehicle	0.23	0.0002	1.41	0.016
Fill with 4 gallons Fuel H	4.23	0.0002	5.41	0.016
Percent Ethanol by Calculation	0.00%		0.30%	
Effectiveness by Calculation	99.9%		95.5%	

Procedure E - Phase II

Initial Sample Ethanol Volume	8.89%		6.85%	
Fill Tank 4 gallons Fuel E	4.23	0.376	5.41	0.371
Drain Vehicle	0.23	0.0204	1.41	0.097
Fill with 4 gallons Fuel H	4.23	0.0204	5.41	0.097
Drain Vehicle	0.23	0.0011	1.41	0.025
Fill with 4 gallons Fuel H	4.23	0.0011	5.41	0.025
Drain Vehicle	0.23	0.0001	1.41	0.007
Fill with 4 gallons Fuel H	4.23	0.0001	5.41	0.007
Percent Ethanol by Calculation	0.00%		0.13%	
Effectiveness by Calculation	100.0%		98.1%	

Prediction of the Results based on Calculations

Performed by Southwest Research Institute

Vehicle Manufacturer	**Toyota**		**Mitsubishi**	
Model	**Corolla**		**Galant**	
System Residual Fuel (gal)	0.23		1.41	
	Total Fuel in Vehicle (gallons)	Ethanol in Fuel (gallons)	Total Fuel in Vehicle (gallons)	Ethanol in Fuel (gallons)

Nissan
Maxima
0.99
9.47%

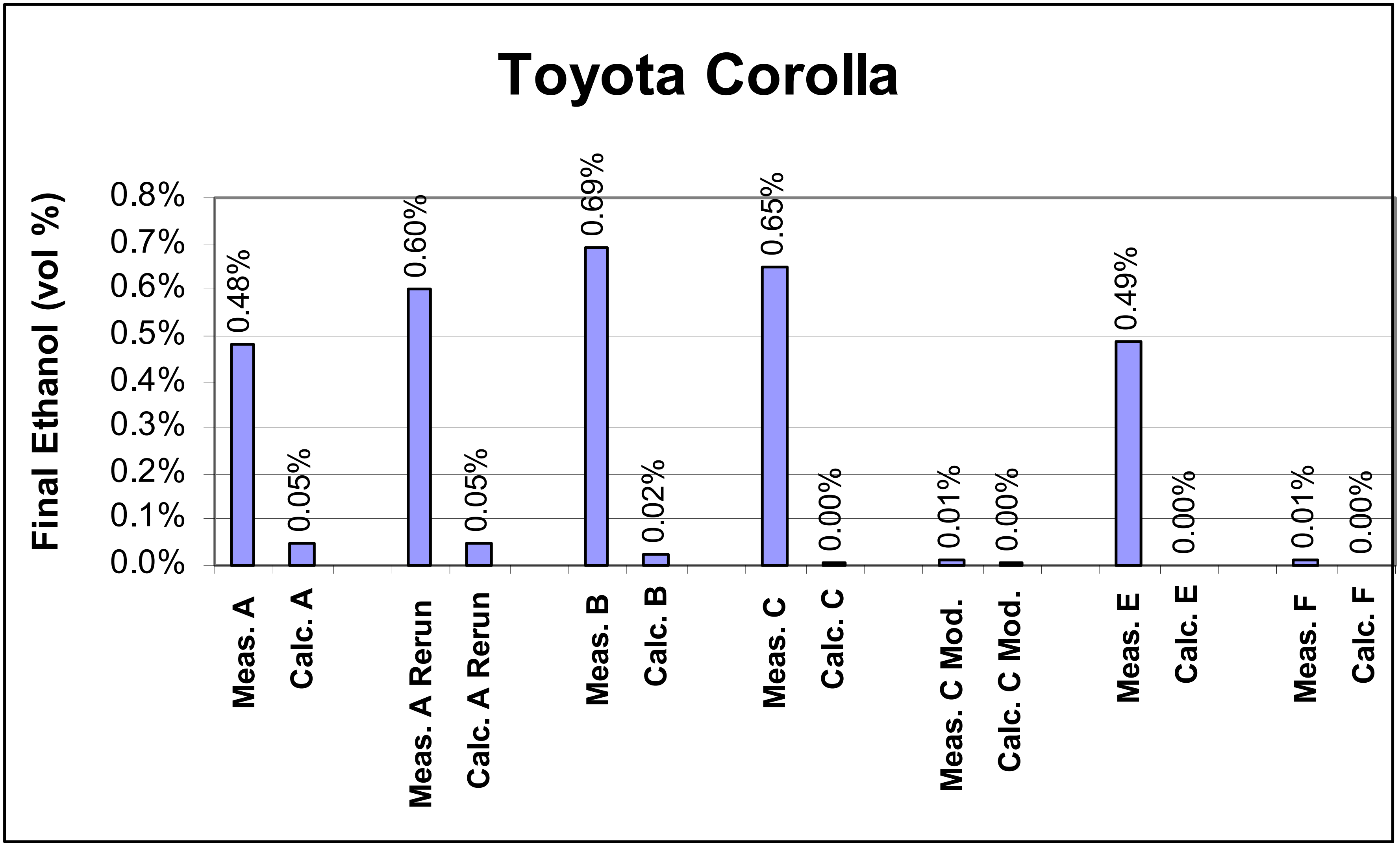
Procedure E Modified - Phase II

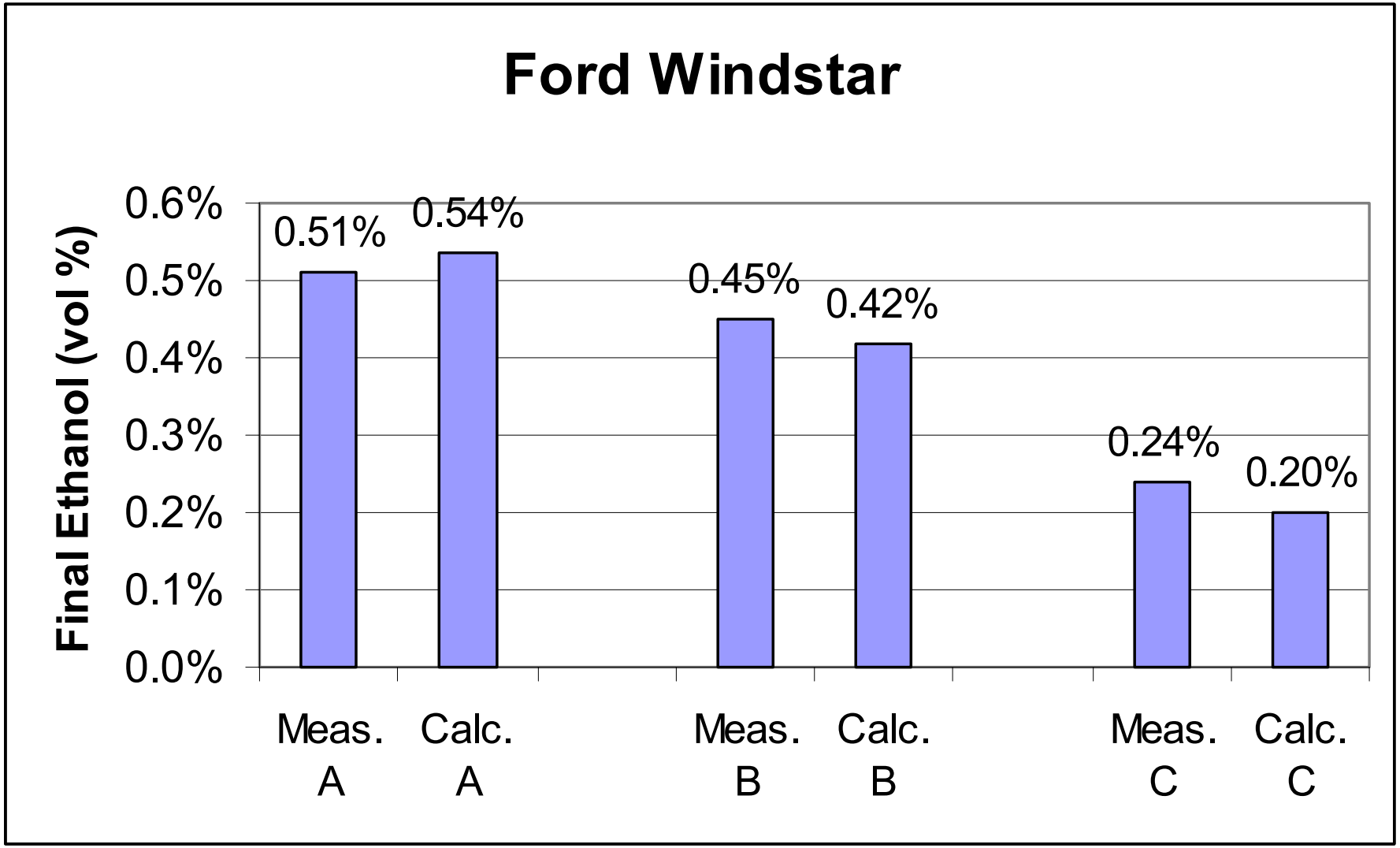
Initial Sample Ethanol Volume			6.84%	
Fill Tank 4 gallons Fuel E			5.41	0.37
Drain Vehicle			1.41	0.096
Fill with 4 gallons Fuel H			5.41	0.096
Drain Vehicle			1.41	0.025
Fill with 4 gallons Fuel H			5.41	0.025
Drain Vehicle			1.41	0.007
Fill with 4 gallons Fuel H			5.41	0.007
Percent Ethanol by Calculation			0.13%	
Effectiveness by Calculation			98.1%	

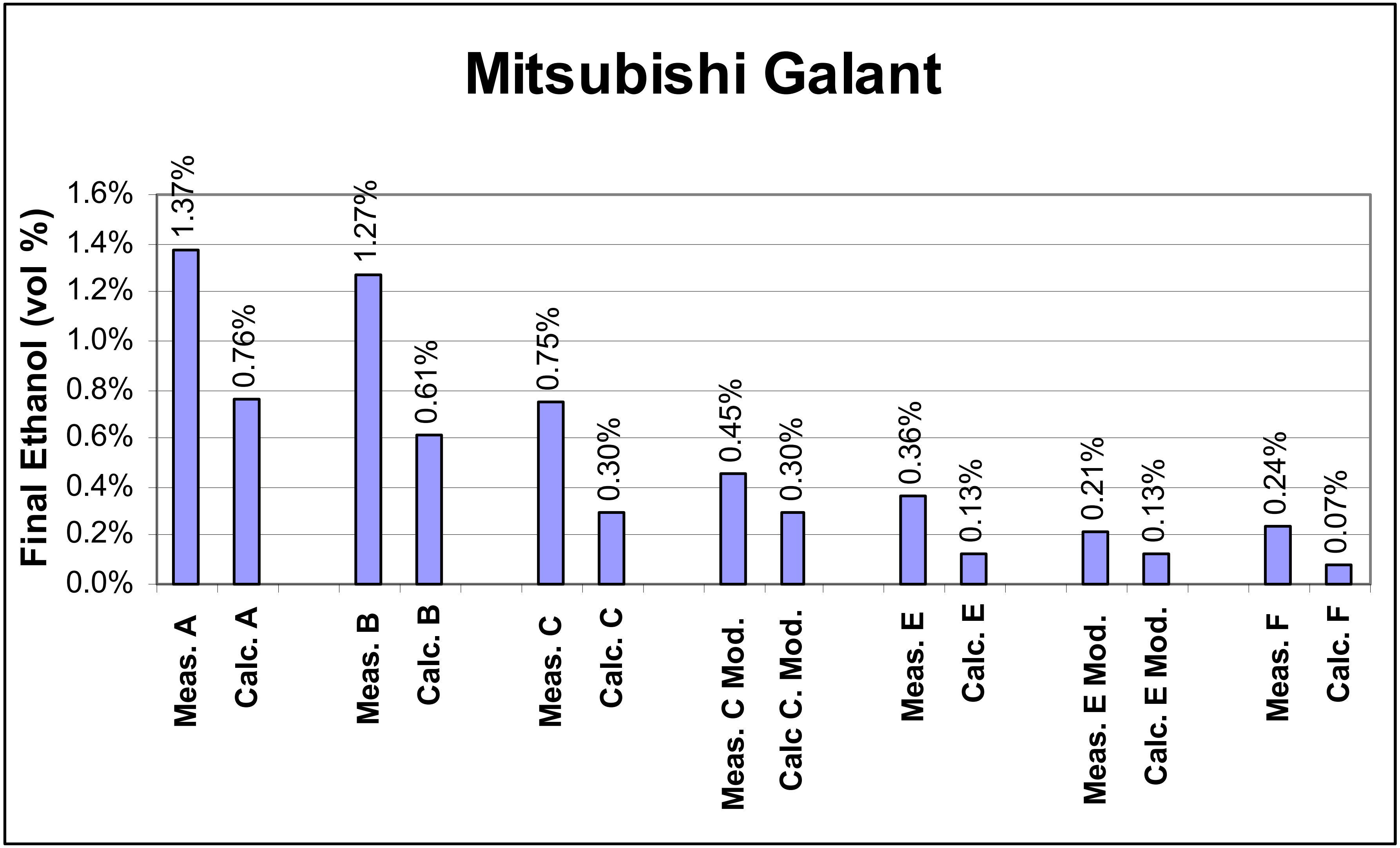
Procedure F - Phase II

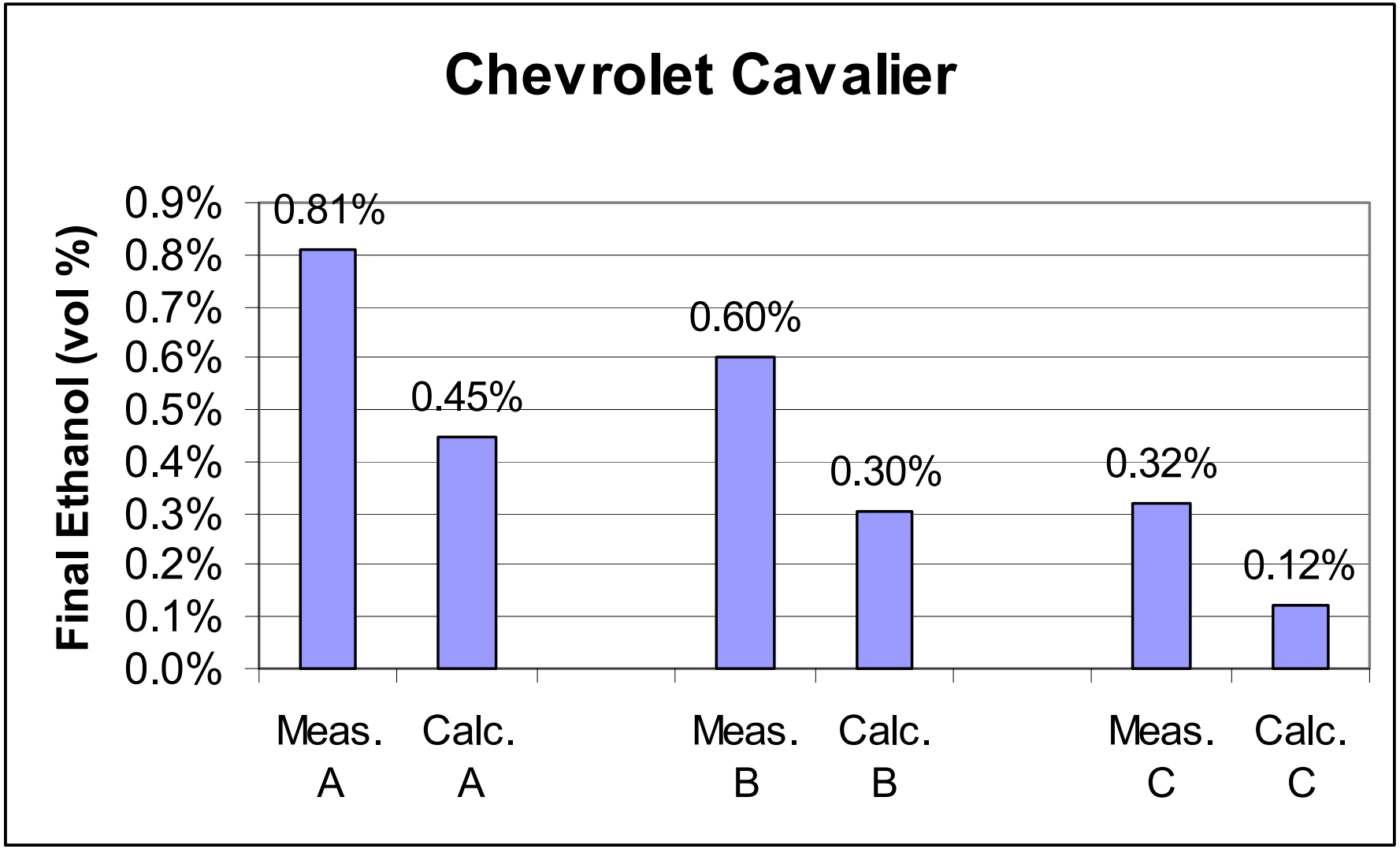
Initial Sample Ethanol Volume	9.12%		6.70%	
Fill Tank 4 gallons Fuel E	4.23	0.3858	5.41	0.362
Drain Vehicle	0.23	0.021	1.41	0.094
Fill with 8 gallons Fuel H	8.23	0.021	9.41	0.094
Drain Vehicle	0.23	0.0006	1.41	0.014
Fill with 4 gallons Fuel H	4.23	0.0006	5.41	0.014
Drain Vehicle	0.23	0	1.41	0.004
Fill with 4 gallons Fuel H	4.23	0	5.41	0.004
Percent Ethanol by Calculation	0.00%		0.07%	
Effectiveness by Calculation	100.0%		98.9%	

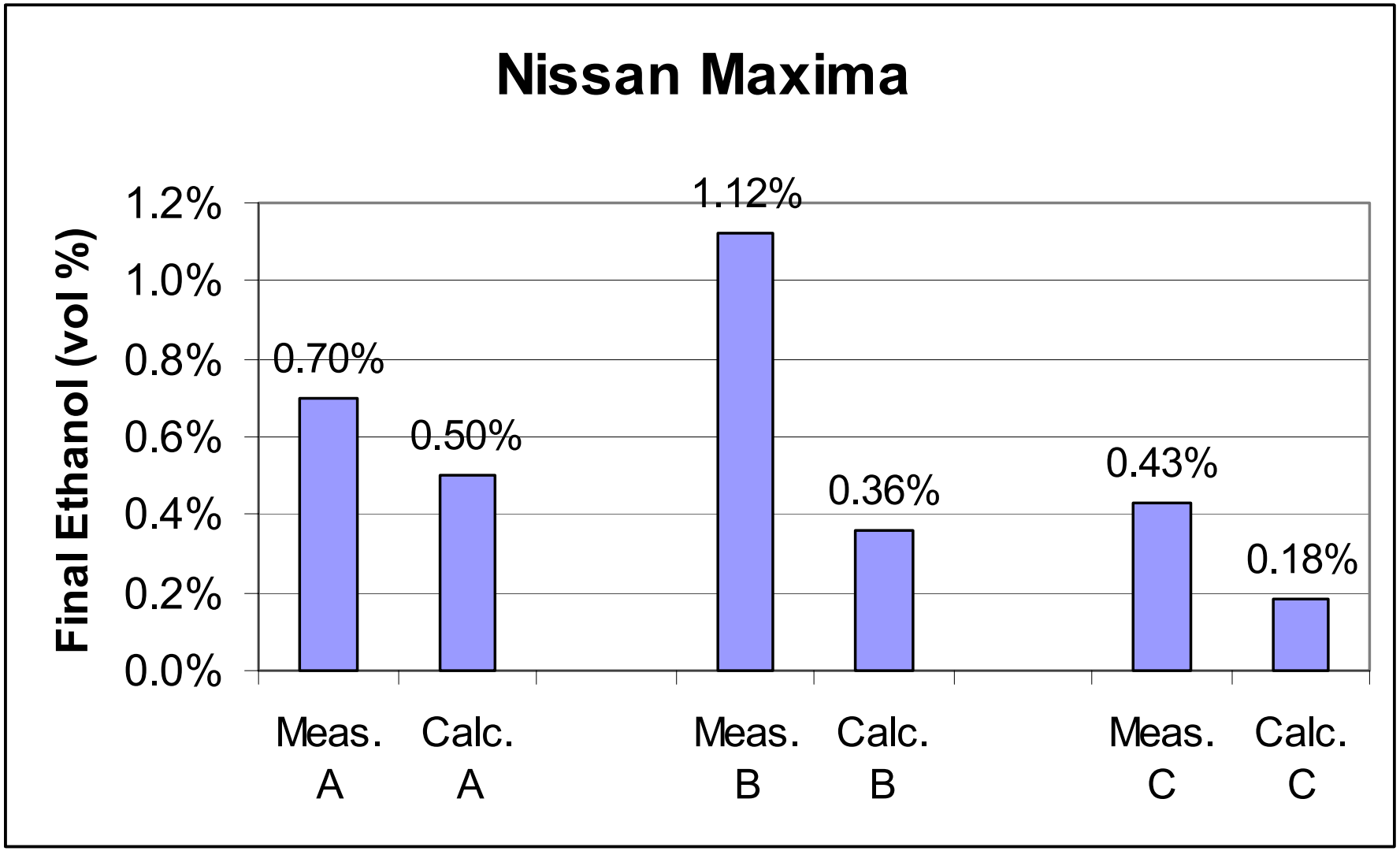
APPENDIX G – MEASURED RESULTS


Toyota Corolla
Final Ethanol (vol %)
0.8%
0.7%
0.6%
0.5%
0.4%
0.3%
0.2%
0.1%
0.0%
0.48%
0.05%
0.60%
0.05%
0.69%
0.02%
0.65%
0.00%
0.01%
0.00%
0.49%
0.00%
0.01%
0.00%
Meas. A
Calc. A
Meas. A Rerun
Calc. A Rerun
Meas. B
Calc. B
Meas. C
Calc. C
Meas. C Mod.
Calc. C Mod.
Meas. E
Calc. E
Meas. F
Calc. F


Ford Windstar
Final Ethanol (vol %)
0.6%
0.5%
0.4%
0.3%
0.2%
0.1%
0.0%
0.51%
0.54%
0.45%
0.42%
0.24%
0.20%
Meas. A
Calc. A
Meas. B
Calc. B
Meas. C
Calc. C


Mitsubishi Galant
Final Ethanol (vol %)
1.6%
1.4%
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
1.37%
0.76%
1.27%
0.61%
0.75%
0.30%
0.45%
0.30%
0.36%
0.13%
0.21%
0.13%
0.24%
0.07%
Meas. A
Calc. A
Meas. B
Calc. B
Meas. C
Calc. C
Meas. C Mod.
Calc C. Mod.
Meas. E
Calc. E
Meas. E Mod.
Calc. E Mod.
Meas. F
Calc. F


Chevrolet Cavalier
Final Ethanol (vol %)
0.9%
0.8%
0.7%
0.6%
0.5%
0.4%
0.3%
0.2%
0.1%
0.0%
0.81%
0.45%
0.60%
0.30%
0.32%
0.12%
Meas. A
Calc. A
Meas. B
Calc. B
Meas. C
Calc. C


Nissan Maxima
Final Ethanol (vol %)
1.2%
1.0%
0.8%
0.6%
0.4%
0.2%
0.0%
0.70%
0.50%
1.12%
0.36%
0.43%
0.18%
Meas. A
Calc. A
Meas. B
Calc. B
Meas. C
Calc. C